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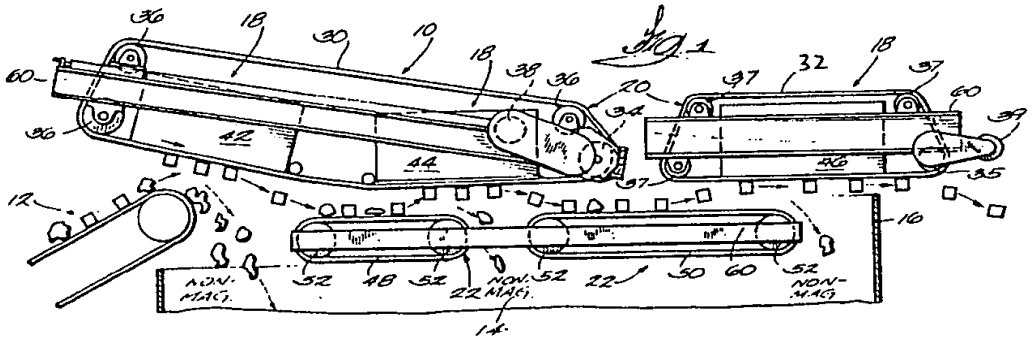
(54) Magnetic separator

(57) A magnetic separator comprises at least two horizontally-spaced magnetic field-generating means (18), and conveying means (20) associated with the magnetic field-generating means and supported to move serially through the magnetic fields generated thereby. The magnetic field-generating means are spaced sufficiently to produce at least one gap between their magnetic fields such that magnetic articles attracted to the conveying means (20) by one of the magnetic fields fall away from the conveying means at the gap(s). The magnetic separator also comprises horizontal conveying means (22) below and facing the conveying means (20) and supported beneath the gap(s) to receive magnetic articles falling from the conveying means (20) after being attracted by one of the magnetic fields, and to transport the fallen magnetic articles to the next magnetic field where they are again attracted to the conveying means (20). As shown, three magnetic-field-generating means define two gaps.



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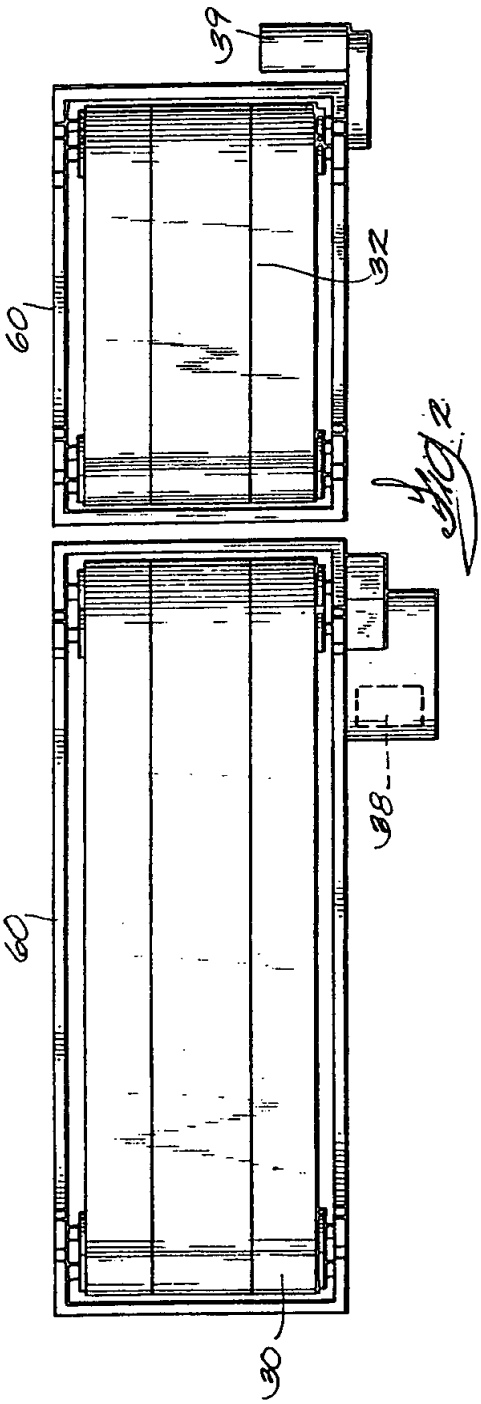

Fig. 2

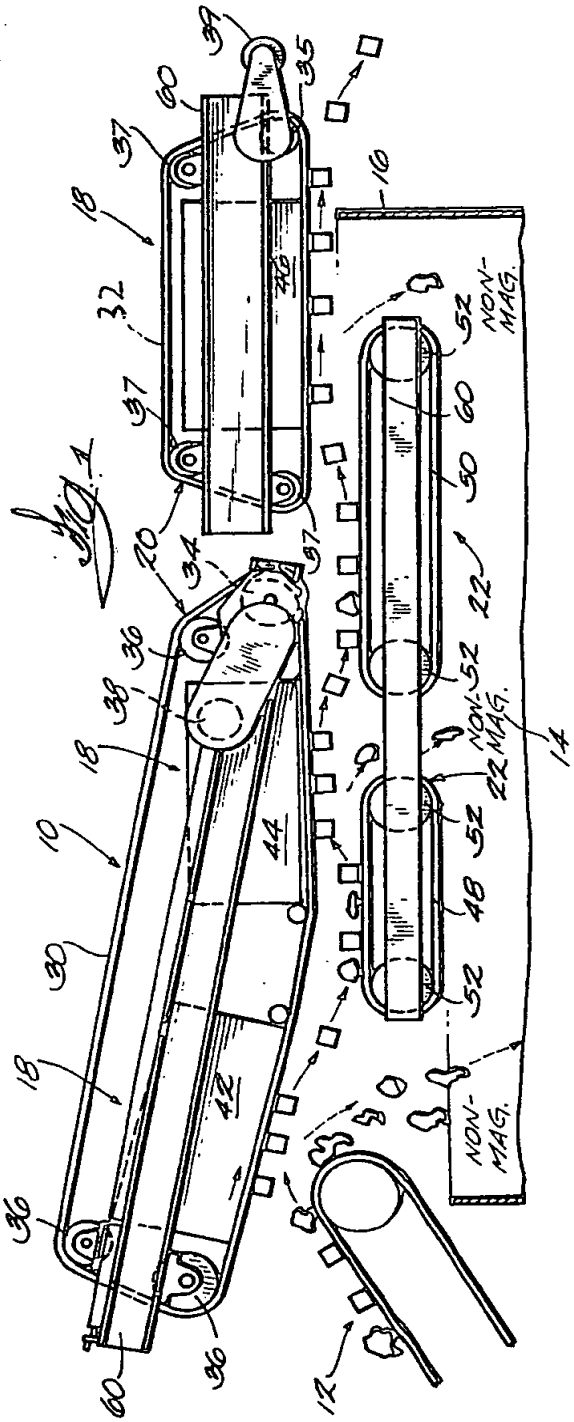

Fig. 1

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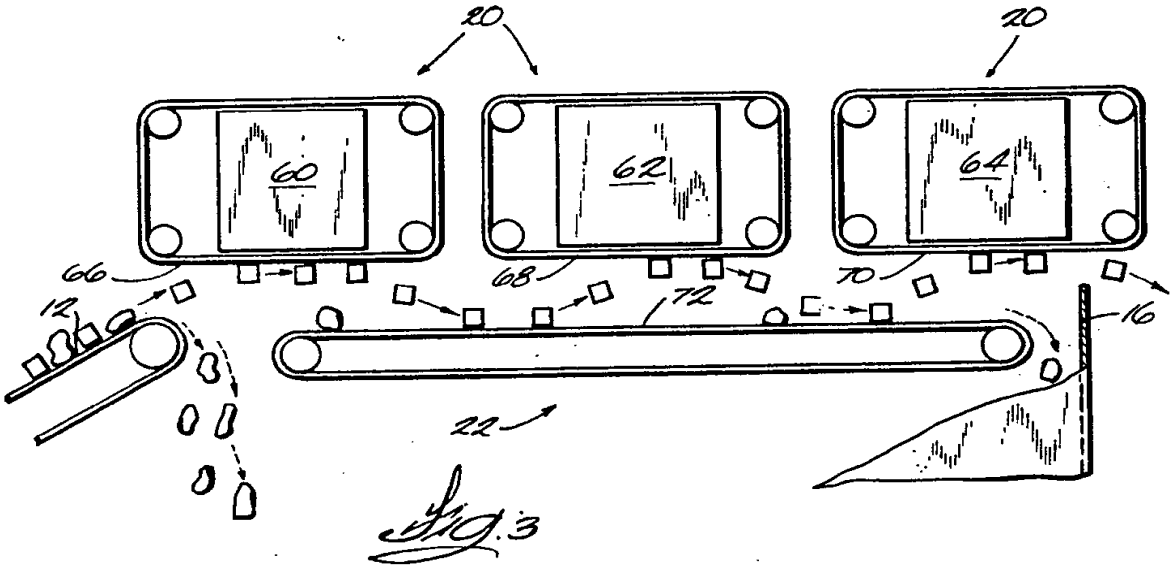

Fig. 3

SPECIFICATION

Magnetic Separator

This invention relates to magnetic separators and is especially useful for the magnetic separation of magnetic material in refuse.

With more and more emphasis being placed on recycling, it is becoming more desirable to recover salvageable articles from otherwise discarded material. Much of the metallic material discarded as refuse can generally be recycled for one purpose or another, provided it can be efficiently separated from the remainder of the refuse. The metallic material intended to be recaptured is generally also magnetic so that magnetic separation is a possibility for recapture. However, nonmetallic material, e.g., paper, is usually light and tangled with the magnetic material and thus subject to being carried along with the magnetic material, making complete separation difficult, if not impossible. Also, in some cases it may be desirable to separate the lighter material (e.g. paper) for recycling.

There are various designs of magnetic separators, disclosed for example in U.S. Patents 3,890,239 and 3,935,947, none of which, to the inventor's knowledge, ensures the complete separation of magnetic material from nonmagnetic material.

One type of magnetic separator provides a continuous belt moving through a magnetic field generated by a magnetic assembly, the magnetic assembly being positioned above a portion of the belt. The magnetic assembly typically comprises a plurality of magnets magnetically coupled together. Magnetic objects are attracted to and carried along the belt, while nonmagnetic objects fall away from the belt and are thereby separated from the magnetic objects. A problem with this type of magnetic separator is that heavy magnetic objects sometimes fall away from the belt as they are transferred from one magnet of the magnetic assembly to another, and are irretrievably lost.

The invention provides a magnetic separator comprising: first, downwards-facing conveying means; means for generating magnetic fields concentrated in two, horizontally-spaced, regions of the first conveying means; and second, generally horizontal conveying means below, and facing the first conveying means, supported beneath a gap between the said two regions to receive magnetic articles falling from the first conveying means at the gap; whereby magnetic articles attracted to one of the regions of the first conveying means and conveyed to the gap drop onto the second conveying means, which conveys them closer to the other region, whereupon they are attracted again to the first conveying means.

A principal advantage of the invention is that it provides an improved means for separating magnetic articles from nonmagnetic articles, this being the picking up, dropping and again picking up of the magnetic articles.

Another advantage of the invention is that magnetic articles need not be conveyed continuously by a single belt from the magnetic field of one magnet to the magnetic field of another.

In order that the invention may be better understood, two preferred embodiments will now be described, by way of example only, with reference to the accompanying drawings, wherein:—

Figure 1 is a side view of a combination refuse separator and supply conveyor;

Figure 2 is a top view of the refuse separator of Figure 1; and

Figure 3 is a schematic view of an alternative embodiment of the refuse separator.

Illustrated in the drawings is a magnetic refuse separator 10 in combination with a supply conveyor 12, a hopper 14, and a splitter baffle 16. The function of the hopper 14 and splitter baffle 16 is to physically segregate separated magnetic and nonmagnetic material. No particular form of either is necessary.

The refuse separator 10 is intended to receive burden from the supply conveyor 12 and carry the magnetic portion of the burden over the splitter baffle 16 while the nonmagnetic portion falls, by reason of gravity, into the hopper 14. To this end, the separator 10 includes a plurality of relatively aligned magnetic field generating portions 18 and first conveying means 20 supported to move serially through the magnetic field generated by the magnetic field generating portions 18. The magnetic field generating portions 18 are spaced relative to each other in the direction of their relative alignment a distance sufficient to produce serial gaps between the magnetic fields generated such that magnetic articles attracted to the first conveying means 20 by one of the magnetic fields fall away from the first conveying means 20 at the gaps. The separator 10 further includes second conveying means 22 below the first conveying means 20 and supported at the gaps to receive magnetic articles falling from one of the magnetic fields and to transport the fallen magnetic articles to the next magnetic field where they are again attracted to the first conveying means 20.

While various suitable first conveying means 20 could be employed, in the preferred embodiment, the first conveying means 20 comprises a pair of conveyor belts 30 and 32, each of which moves around a closed path, and, in the illustrated construction, in a counter-clockwise manner. Belt 30 moves around pulleys or rollers 34 and 36 and has a generally horizontal lower extension. The drive pulley 34 is connected to a drive motor 38 through a drive belt 40 so that belt 30 is driven by the drive pulley 34. Thus, belt 30 travels in a continuous closed path under the influence of the drive pulley 34.

Belt 32 also moves around pulleys or rollers 35 and 37 and has a generally horizontal lower extension. The drive pulley 35 is connected to a drive motor 39 through a drive belt so that belt 32 is driven by the drive pulley 35.

In the preferred embodiment, the magnetic field generating portions 18 are conventional electromagnets 42, 44 and 46. The magnets are spaced apart a sufficient distance so that the magnetic flux in the gap between the magnets is

either reduced to zero or diminished to a point where magnetic articles are not attracted.

It should be appreciated that the magnetic field generating portions 18 could also be permanent magnets or a combination of electromagnets and permanent magnets. Electromagnets afford a possible safety advantage when work must be done in the area of the separator in that they can be turned off and cleared of all material.

While other suitable means could be used, in the preferred embodiment the second conveying means 22 comprises conveyor belts 48 and 50 positioned generally between the magnets 42, 44, and 46. Each belt moves continuously around a pair of rollers 52, with one of the rollers 52 being driven by a drive motor (not shown) in a manner similar to that in which the drive motor 38 drives belt 30. Each belt has a generally horizontal upper extension. In the illustrated construction, belts 48 and 50 move in a clockwise manner so that the upper extensions of belts 48 and 50 are moving in the same direction as the lower extensions of belts 30 and 32.

Belts 48 and 50 are positioned generally between magnets 42, 44, and 46 such that articles released in one of the gaps and falling away from one of belts 30 and 32 fall onto one of belts 48 and 50 and are conveyed by the belt to the magnetic field of the next magnet. At this point, the magnetic articles are again attracted to belt 30 or 32 adjacent the next magnet, whereby nonmagnetic articles carried with the magnetic articles are separated therefrom.

The belts and magnets may be supported by any suitable frame structure, and a portion of a frame structure 60 is illustrated in Fig. 1. A complete showing of the structural framework of the separator 10 is not necessary to an understanding of this invention, and a general description of the support structure is believed to be adequate. Also, the upper belts 30 and 32 should be adjustable vertically with respect to the supply conveyor 12 and the lower belts 48 and 50, or vice versa, and the lower belts 48 and 50 should be adjustable horizontally with respect to the upper belts 30 and 32, or vice versa. The details of an adjustable mounting are not shown, but if details of such a mounting are desired, reference may be had to the aforementioned U.S. Barret Patent 3,809,239.

In operation, as shown in Fig. 1, the conveyor 12 carries burden into the magnetic field of magnet 42 and the magnetic material contained in the burden is attracted to belt 30 by magnet 42. The nonmagnetic material such as paper will fall by gravity into the hopper 14, and the magnetic material travels with belt 30. However, paper and like nonmagnetic material, being relatively light, is prone to being tangled with the magnetic material and carried along with it into engagement with belt 30 such that it cannot fall into the hopper 14. To provide improved means for dislodging this entrapped nonmagnetic material, this invention provides for dropping and picking up of the burden carried by belt 30.

More specifically, a magnetic article is initially attracted to belt 30 by magnet 42. The magnetic article is then conveyed through the magnetic field of magnet 42 (to the right in Fig. 1) until it reaches the gap between magnets 42 and 44. Since there is no attractive force in the gap holding the magnetic article on belt 30, the magnetic article will fall, due to gravity, onto belt 48. During the course of tumbling through the air and landing on belt 48, any nonmagnetic articles that were entangled with the magnetic article should become separated therefrom.

Belt 48 then conveys the magnetic article and any nonmagnetic articles that have fallen thereon into the magnetic field of magnet 44. Here the magnetic article is again attracted to belt 30, while any nonmagnetic articles that were carried to belt 48 with the magnetic article will remain on belt 48 until they fall from the end of the upper extension of belt 48 into the hopper 14.

After being again attracted to belt 30, the magnetic article is conveyed by belt 30 through the magnetic field of magnet 44. Upon reaching the gap between magnets 44 and 46, the magnetic article again falls away from belt 30, this time onto belt 50, and the process of separating nonmagnetic articles from the magnetic article is repeated. Any nonmagnetic articles that were carried by the magnetic article to belt 50 are deposited into the hopper 14 at the end of the upper extension of belt 50, while the magnetic article is attracted to belt 32 in the magnetic field of magnet 46. Belt 32 conveys the magnetic article through the magnetic field of magnet 46 and over the splitter baffle 16, where the magnetic article is then dropped from the separator 10 into an area separated from the hopper 14.

An additional advantage of this invention, along with improved separation of magnetic and nonmagnetic articles, is that magnetic articles need not be conveyed continuously by a single belt from the magnetic field of one magnet to the magnetic field of another. This is sometimes a problem in that heavy magnetic objects tend to fall off as they are transferred from one magnet to another. This invention does not attempt to do this, as each magnet picks up and drops the magnetic articles.

Illustrated in Figure 3 is an alternative embodiment of the invention. The magnetic field generating portions are magnets 60, 62, and 64. The first conveying means 20 comprises three separate belts 66, 68, and 70, with belt 66 moving along a continuous path around magnet 60, belt 68 moving along a continuous path around magnet 62, and belt 70 moving along a continuous path around magnet 64. The second conveying means 22 comprises a single belt 72 extending from beneath magnet 60 to beneath magnet 64, and moving along a continuous path having a generally horizontal upper extension.

In the construction illustrated in Fig. 3, belts 66, 68, and 70 move counter-clockwise, and belt 72 moves clockwise.

In operation, the conveyor 12 carries burden into the magnetic field of magnet 60 and the magnetic material contained in the burden is thereby attracted to belt 66. The magnetic material is then carried by belt 66 to the gap between magnets 60 and 62, where it is dropped onto belt 72, whereby it is

carried into the magnetic field of magnet 62, where it is attracted to belt 68. The magnetic material is next carried by belt 68 to the gap between magnets 62 and 64, where it is dropped again onto belt 72, whereby it is carried into the magnetic field of magnet 64, where it is attracted to belt 70. The magnetic material is finally carried by belt 70 over the splitter baffle 16, where it is dropped in an area separated from nonmagnetic material. Meanwhile, nonmagnetic material carried with the magnetic material to belt 72 is deposited from the end of belt 72 on the side of the splitter baffle 16 opposite the side on which magnetic material is deposited.

It should be appreciated that many other combinations of magnets and conveying means are within the scope of the invention, and that the conveying means need not be conveyor belts. Any means conveying the magnetic material through the magnetic fields will do. Furthermore, the invention does not require more than two magnetic field generating portions, or, alternatively stated, more than one gap. Depending on the nature of the refuse to be separated, one gap may be sufficient. Additional gaps, or additional dropping and picking up of magnetic material, simply increase the likelihood of complete separation of magnetic and nonmagnetic material.

CLAIMS

1. A magnetic separator comprising: first, downwards-facing conveying means; means for generating magnetic fields concentrated in two, horizontally-spaced, regions of the first conveying means; and second, generally horizontal conveying means below, and facing, the first conveying means, supported beneath a gap between the said two regions to receive magnetic articles falling from the first conveying means at the gap; whereby magnetic articles attracted to one of the regions of the first conveying means and conveyed to the gap drop onto the second conveying means, which conveys them closer to the other region, whereupon they are attracted again to the first conveying means.

2. A magnetic separator according to Claim 1, wherein the field-generating means comprises a plurality of relatively aligned magnetic field-generating means, the first conveying means being associated with said magnetic field-generating means and supported to move serially through the magnetic fields generated by said magnetic field-generating means, said magnetic field-generating means being spaced relative to each other in the direction of their relative alignment a distance sufficient to produce serial gaps between the magnetic fields generated such that magnetic articles attracted to said first conveying means by one of the magnetic fields fall away from said first conveying means at said gaps; and wherein the second conveying means below said first conveying means are supported at said gaps to receive magnetic articles falling from one of the magnetic fields and to transport said fallen magnetic articles to the next magnetic field where said magnetic articles are again attracted to said first conveyor means.

3. A magnetic separator according to Claim 1, wherein the field-generating means is supported adjacent said first conveying means to generate an attractive magnetic field through which said first conveying means moves, said magnetic field-generating means including a first magnetic field-generating portion and a second magnetic field-generating portion, said second field-generating portion being spaced horizontally a predetermined distance from said first field-generating portion in the direction of movement of said first conveying means along a generally horizontal path to provide the gap in the magnetic field generated by said magnetic field-generating means so that magnetic articles attracted to said first conveying means in the area of said first field-generating portion are released in said gap and fall away from said first conveying means and wherein the magnetic separator comprises means for moving said second conveying means along a generally horizontal path and into the attractive magnetic field generated by said second magnetic field-generating portion so that magnetic articles falling from said first conveying means at said gap are conveyed by said second conveying means along said horizontal path to the magnetic field of said second magnetic field-generating portion and are again attracted to said first conveying means in the area of said second field-generating portion, whereby nonmagnetic articles carried with said magnetic articles are separated therefrom.

4. A magnetic separator according to Claim 3, wherein said magnetic field-generating means further comprises a third magnetic field-generating portion spaced horizontally a predetermined distance from said second field-generating portion in the direction of movement of said first conveying means along said generally horizontal path to provide a second gap in the magnetic field generated by said magnetic assembly so that magnetic articles attracted to said first belt means in the area of said second field-generating portion are released in said second gap and fall away from said first conveying means; and further comprising third conveying means, means supporting said third conveying means for movement along a horizontal path and with a portion of said third conveying means facing generally upwardly and being positioned generally between said second magnetic field-generating portion and said third magnetic field-generating portion so that magnetic articles released in said second gap and falling away from said first conveying means fall onto said third conveying means, and means for moving said third conveying means along said horizontal path and into the attractive magnetic field generated by said third magnetic field-generating portion so that magnetic articles falling from said first conveying means at said second gap are conveyed by said third conveying means along said horizontal path to the magnetic field of said third magnetic field-generating portion and are again attracted to said first conveying means in the area of said third

field-generating portion, whereby nonmagnetic articles carried with said magnetic articles are separated therefrom.

5. A magnetic separator according to any preceding claim, wherein the first conveying means comprises a conveyor belt.

6. A magnetic separator according to any preceding claim, wherein the second conveying means comprises a conveyor belt.

7. A magnetic separator according to Claim 4, or to any claim appendant thereto, wherein the third conveying means comprises a conveyor belt.

8. A magnetic separator substantially as described herein with reference to Figures 1 and 2 of the accompanying drawings.

9. A magnetic separator substantially as described herein with reference to Figure 3 of the accompanying drawings.

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